Where, Oh Where, Should We Plant SAV?

Developed by Martha Shaum, Aquatic Resources Education Program, Maryland Department of Natural Resources

Overview: Students use real-time data to determine appropriate planting areas for SAV.

Objectives:

Students will be able to:

- Establish which water quality parameters determine where certain species of SAV will grow and thrive.
- Use the "Eyes on the Bay" website to determine suitable areas to plant SAV.

Grade Level: Middle School

Subject Areas: Environmental science, earth science

Duration: 45-90 minutes

Materials:

- Computers with internet access
- "Water Quality and SAV" Student Background
- "Where, Oh Where, Should We Plant SAV?" Student Worksheet
- Map of Maryland

Maryland Voluntary State Curriculum:

Middle School	1.A.1	Design, analyze, or carry out simple investigations and formulate appropriate conclusions based on data obtained or provided.
	1.B.1	Review data from a simple experiment, summarize the data, and construct a logical argument about the cause-and-effect relationships in the experiment.
Grade 6	3.D.1	Explain that in any particular environment, the growth and survival of organisms and species depend on the physical conditions.
	3.F.1.a	Explain that populations increase or decrease relative to the availability of resources and the conditions of the environment.
Grade 7	6.B.1	Recognize and describe that environmental changes can have local, regional and global consequences.
Grade 8	3.D.1.a	Recognize and describe that gradual (climatic) and sudden (floods and fires) changes in environmental conditions affect the survival of organisms and populations.
	6.B.1	Recognize and explain how human activities can accelerate or magnify many naturally occurring changes.

Teacher preparation…

If your students have not studied salinity, you may want to start with the "Eyes on Salinity" lesson from the Eyes on the Bay curriculum: http://mddnr.chesapeakebay.net/eyesonthebay/lesson_plans/salinity_lesson_plan.pdf.

This also serves as an introduction to the Eyes on the Bay website.

Teacher Background:

Wild celery, sago pondweed and redhead grass are primarily freshwater species, although they are occasionally found in slightly brackish waters (up to 10 ppt). At the upper end of the salinity range, the plants may survive, but are usually stressed, meaning that they may fail to grow and/or reproduce. In addition, all SAV requires water with low turbidity in order to receive the amount of sunlight necessary for photosynthesis. Scientists have determined that SAV needs turbidity values less 15 NTUs or a Secchi depth reading greater than 0.7 meters in order to thrive.

In this exercise, students will be accessing data from the "Eyes on the Bay" website (www.eyesonthebay.net). They will be using data from continuous monitoring stations because these stations are located in shallow water adjacent to shore. Most of these stations are located in water that is less than 2 meters deep – in other words, water that is shallow enough that students could theoretically plant SAV. At these stations, turbidity is measured in NTUs rather than Secchi depth.

Water Quality and SAV

Salinity

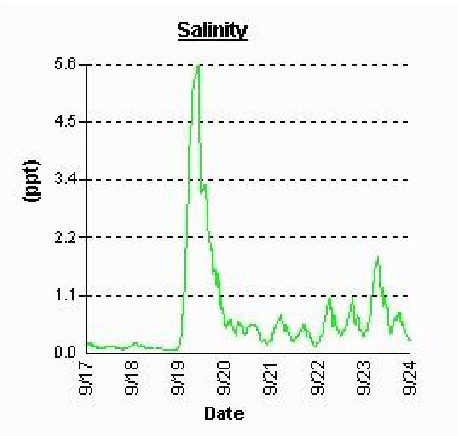
Salinity is the amount of salt, mainly sodium chloride, in the water. Salinity levels range from 0 ppt (parts per thousand) in fresh water to 35 ppt in the ocean. The salts in the ocean come from the erosion of minerals from the land and over the eons, the ocean is slowly becoming saltier.

In estuaries like the Bay, where salt water from the ocean mixes with fresh water from the rivers, the salinity at any given point depends largely on location. Obviously, the salinity is higher closer to the mouth of the Bay, and closer to the middle of the Bay than near the mouth of a river. Salinity is also higher on the Eastern Shore than the Western Shore due to the Coriolis effect and the fact that there are fewer rivers entering the Bay from the Eastern Shore.

Coriolis effect: the tendency for any moving body on or above the earth's surface, e.g., an ocean current or an artillery round, to drift sideways from its course because of the earth's rotation.

For SAV, salinity is the major factor that determines where a specific species can grow. For example, eelgrass prefers high salinity water, and is seldom found north of the

Choptank River. On the other hand, coontail and elodea prefer fresh water, and are usually found in the upper reaches of the tributaries. Some species can grow in a wider range of salinity, and are found in both fresh and moderately brackish water.



Storm Surge from TS Isabel (2003) – Deep Landing, Chester River

Sudden extreme changes in salinity are usually caused by weather conditions. For example, a heavy rain, especially one that accompanies a tropical storm, will dilute salt water. A storm surge, such as the one that occurred during Hurricane Isabel, can drive salt water far up into fresh water rivers.

For great storm surge animations, go to http://www.weatherwizkids.com/hurricane1.htm

Some species of SAV are very sensitive to increases in salinity even for short periods of time. Other species can survive as long as the change is not too extreme or long-lasting.

A drought, on the other hand, will cause an increase in salinity, and the effects of a drought tend to be more prolonged. A drought, obviously, has a profound effect on the survival of SAV.

Turbidity

Turbidity measures how clear the water is; turbid water looks cloudy and has high levels of total suspended solids. Turbidity is caused when sediment is stirred up in the water, or soil washes off the land (erosion). Excessive growth of algae can also cause the water to become cloudy. High turbidity may also be caused by waste discharge, urban runoff, and abundant bottom feeders (such as carp) that stir up bottom sediments. A prolonged drought often improves turbidity readings by reducing the amount of soil and nutrients that are washed into the Bay.

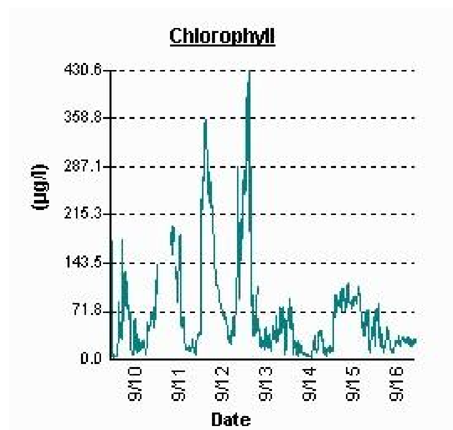
Turbidity can be measured in several ways. A Secchi disk is a circular plate with alternating black and white quarters. It is lowered into the water until it is no longer visible and the depth is measured. Secchi depths that are high are considered clear and vice versa. A Secchi disk is difficult to use in fast flowing rivers because the current will push the disk downriver, preventing an accurate measurement. It does not provide an exact measure of turbidity, but it is an inexpensive way to measure water clarity. Turbidity can also be measured more accurately using a transmissometer which measures the scattering of light and reports turbidity as Nephelometric Turbidity Units (NTUs).

All plants need sunlight to photosynthesize and SAV is no exception. Therefore, turbidity is considered to be the most important factor in determining whether SAV will survive since the sunlight needs to penetrate the water to reach the leaves of the submerged plants. If the water becomes too cloudy, adequate sunlight cannot reach the plants; the deeper the plants are, the clearer the water needs to be. Scientists have demonstrated that submerged aquatic vegetation cannot grow if the turbidity values are over 15 NTUs or if Secchi depth is less than 0.7 meters. Any increase in turbidity decreases sunlight penetration and reduces the amount of oxygen produced by aquatic plants.

For a Secci Disc animation with a description of turbidity, go to
http://oceanservice.noaa.gov/education/kits/estuaries/media/supp_estuar10e_turbinity.html

Chlorophyll

Chlorophyll is the main molecule that allows plants to perform photosynthesis and convert sunlight into food energy. Many people, when they think about plants in the Bay, think of submerged aquatic vegetation (SAV), but much of the photosynthesis that occurs in aquatic habitats is being done by algae. Therefore, scientists measure chlorophyll concentrations in the Chesapeake and Coastal Bays because it allows them to determine the amount of algae in the water. Concentrations are measured in micrograms per liter (µg/l).



Baltimore Harbor September 2008

Algae are a natural and crucial part of aquatic ecosystems because they form the bottom of many complex food webs. They range in size from tiny one-celled plants (phytoplankton) which float in the water to visible, multi-celled "macroalgae", the green slimy mats that cling to any relatively solid object. When algae occur in unusually high concentrations, however, a harmful algae bloom (HAB) results. Sometimes these blooms are so severe that the water actually changes color, and the result is a "red tide", "brown tide", "mahogany tide", etc. depending on the alga involved. Chlorophyll concentrations above 50 µl/l are considered a significant bloom and concentrations above 100 µg/l are considered a severe bloom.

For more information, see "Eyes on Harmful Algal Blooms":
http://mddnr.chesapeakebay.net/eyesonthebay/lesson_plans/hab_lesson_plan.pdf.

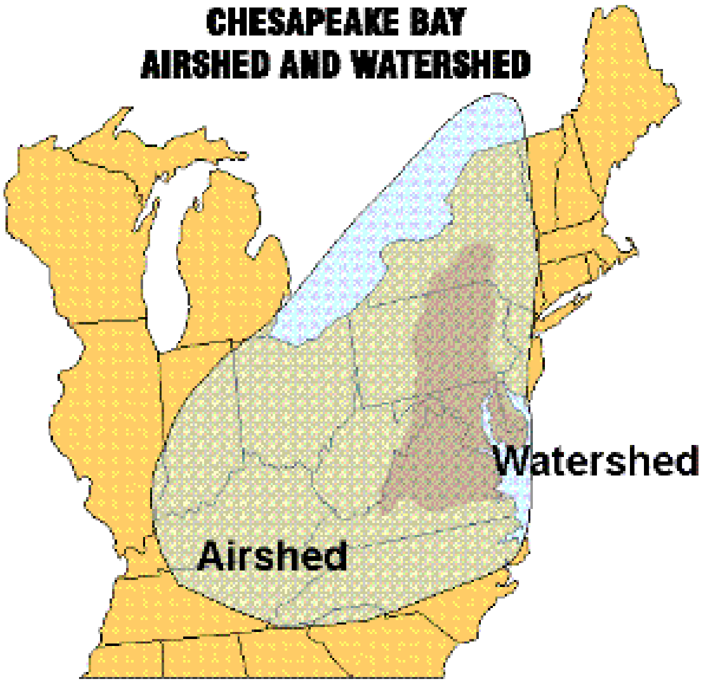
A heavy bloom of phytoplankton causes an increase in turbidity, blocking the sunlight needed by submerged aquatic vegetation. Mahogany tides have been associated with widespread harmful impacts, including loss of SAV. An excessive amount of macroalgae can form dense mats which reduce the available sunlight by covering the surface of the water or clinging to the SAV.

Nitrogen

Nitrogen is an element that is required by all plants and animals to build proteins. In the water, blue-green algae convert molecular nitrogen (N_2) into ammonia (NH_3), which can be used as a nutrient by other algae and submerged aquatic vegetation. Specialized bacteria break down the ammonia to form nitrites and nitrates, which plants have to convert back into ammonia before they can use the nitrogen.

Some of the nitrogen entering the water enters as run-off from the land. Ammonia or nitrates are the main nitrogen sources in the fertilizers used by farmers. If more fertilizer is applied than the plants can use, the excess runs off, either directly into a stream or river or into the ground water. Animal waste, whether from large livestock operations like chicken or dairy farms or from pet waste, also contributes nitrogen. Human sewage from poorly functioning sewage treatment plants or septic systems adds its share of nitrogen.

The other source of nitrogen is what is called "atmospheric deposition" – nitrogen in the air. Most of the focus has been on nitrogen oxides from power plants, automobile emissions or anything else that burns fossil fuels. But scientists are now beginning to realize that a substantial source of airborne ammonia may be large livestock operations. (Anyone who has ever stood near a barnyard or chicken house has smelled the ammonia in the air.) This airborne ammonia may be coming from as far away as Ohio or North Carolina.



Regardless of where the nitrogen is coming from, when it ends up in the water, especially salt water, it acts as a nutrient and triggers a rapid growth of algae. These algae blooms increase the turbidity and reduce the amount of sunlight that reaches the SAV.

Activity:

1. Have students read "Water Quality and SAV: Student Background". Review or brainstorm the water quality parameters necessary for SAV to grow and thrive:

    - Wild celery, sago pondweed and redhead grass prefer fresh water, but can grow in slightly brackish water up to about 10 ppt.
    - Explain that for this activity, the important water quality parameters they will be focusing on are **salinity** and **turbidity**.
    - Your students should know that they will be planting their SAV in shallow water (along the shoreline somewhere).
    - Tell them that scientists estimate that the shoreline of the Chesapeake Bay and its tidal tributaries (including tidal wetlands and islands) is over 11,000 miles. That's more shoreline than the entire west coast of the United States.
    - Short of going around and testing miles of shoreline, how could they decide where to plant their SAV?
    - Explain that there are monitoring stations all over the Maryland portion of the Bay and rivers. These stations monitor a number of water quality parameters. The data from these stations are available online. They are going to access this data to make their decision.

2. Divide the students into groups depending on the number of available computers. Hand out the Student Worksheet and Data Table. The worksheet will tell them how to access the data. Give the students time to find the data and fill out the Data Table. They may have to estimate an average turbidity value. Remind them that SAV needs an **average** turbidity value of 15 NTUs or less, but that an occasional short-lived spike probably will not cause any harm.

Answers to Student Worksheet:
Analysis:

1. What would be the best place(s) to plant your SAV? Discuss your results with other students to see if you agree. *Students should agree that the Chesapeake Bay Susquehanna Flats and the Susquehanna River Havre de Grace sites have the best water quality. They also might agree that the Chester River Kent Narrows Inside and the Patapsco River Baltimore Harbor might work too, although the salinity is a little high. Students may be surprised at how few sites were suitable. They may also be surprised that Baltimore Harbor was suitable.*
2. Why did you focus on data from April through October? *Because that is the growing season for SAV. During the winter months, the plants are dormant.*
3. Look at a map of Maryland. Locate the sites which you found suitable to plant SAV. What's special about where they're located? Which one is closest to your school? *Water in the upper Bay is mostly fresh water and these species of SAV prefer fresh water. The farther south you go, the saltier the water becomes.*

Results:

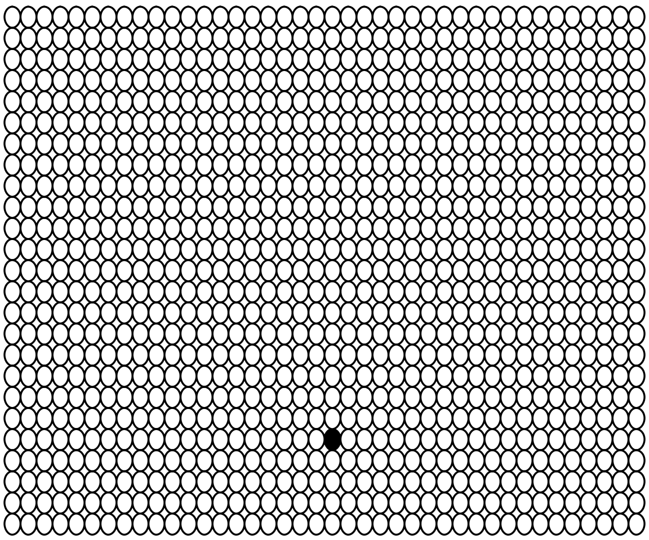
Data Table: Where, Oh Where, Should We Plant SAV?

Location	Salinity Range (ppt)	Average Turbidity (greater or less than 15 NTUs)	Suitable for Wild Celery?	If Not Suitable, Why Not?
Bohemia River Long Point			*No*	*Turbidity too high*
Bush River Otter Point Creek			*No*	*Turbidity too high*
Chesapeake Bay Susquehanna Flats			*Yes*	
Chester River Kent Narrows Inside			*Maybe*	*Salinity is high*
Choptank River High Banks			*No*	*Turbidity too high*
Elk River Hollywood Beach			*No*	*Turbidity too high*
Patapsco River Baltimore Harbor			*Maybe*	*Salinity is high*
Potomac River Breton Bay			*No*	*Salinity too high*
Potomac River Piney Point			*No*	*Salinity too high*
Susquehanna River Havre de Grace			*Yes*	
Wicomico River Whitehaven			*No*	*Turbidity too high*

Water Quality and SAV: Student Background

Salinity

Salinity measures the amount of salt in the water and is usually expressed as parts per thousand (ppt); fresh water is 0 ppt and ocean water is around 35 ppt. The salinity of a body of water determines where each species of SAV can grow. For example, eelgrass prefers high salinity water, while coontail prefers fresh water. Some species can be found in both fresh and slightly brackish water (up to 10 ppt).



What does 'parts per thousand' (ppt) mean? Of these 1000 gumballs, one of them is a different color. If each white circle represented a water molecule, and the black circle represented a salt molecule, we would say the salinity is 1 part per thousand.

Sudden changes in salinity are usually caused by weather. A heavy rain following a tropical storm will lower the salinity. A storm surge, like the one caused by Hurricane Isabel, can cause a sudden increase in salinity. Some species of SAV will be killed by an increase in salinity, even if it lasts for only a short time. Other species can survive as long as the change does not last too long.

Hurricane Isabel

What is storm surge?

The high winds caused by hurricanes (like Isabel) and tropical storms push water towards the storm's center. The storm carries this mound of water toward the land, causing devastating floods. The salty seawater pushed in by the storm surge can also raise the salinity of a bay or river.

A severe drought, however, will cause an increase in salinity that may last a long time. Many species of SAV cannot survive the higher salinity.

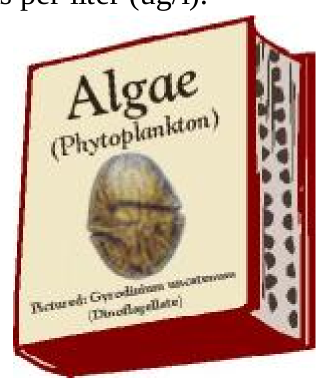
Turbidity

Turbidity measures how clear the water is. Turbidity can be determined by using a Secchi disk and measuring how deep the disk can be lowered into the water before it cannot be seen. A more accurate way is to use an instrument called a transmissometer which reports turbidity as NTUs (Nephelometric Turbidity Units). Turbidity can be caused when sediment is stirred up in the water, when soil washes off the land (erosion) or by too much algae in the water column.

Turbidity is considered to be the most important factor in determining whether SAV will survive. All plants need sunlight to photosynthesize so sunlight needs to be able to penetrate the water to reach the leaves of the SAV. The deeper the plants are growing, the clearer the water needs to be. If the water becomes too cloudy, adequate sunlight cannot reach the plants. Scientists know that SAV needs turbidity levels less than 15 NTUs or Secchi depths greater than 0.7 meters.

Chlorophyll and Nutrients

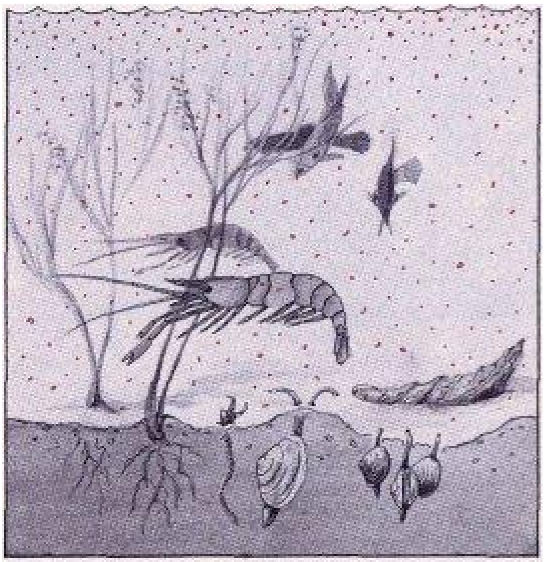
Chlorophyll is the main chemical which allows plants to convert sunlight into food energy – a process known as photosynthesis. Scientists measure chlorophyll concentrations in aquatic habitats because it allows them to determine the amount of algae in the water. Concentrations are measured in micrograms per liter (ug/l).

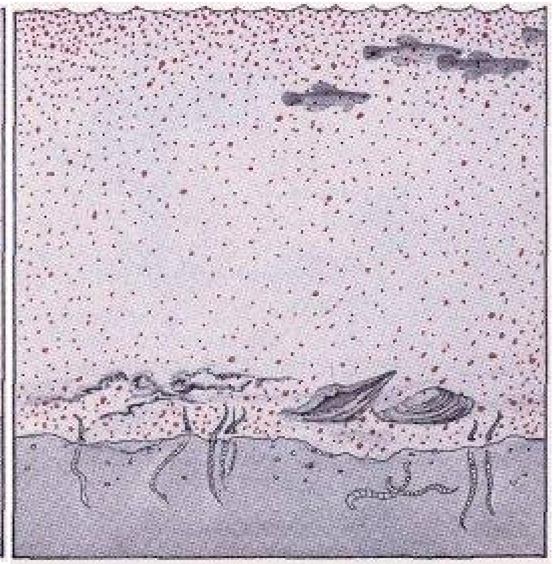


Too much algae, also known as algae blooms, can have serious effects on SAV. Large algae blooms cause the water to become cloudy which affects the amount of sunlight reaching the plants. Large mats of algae can also cover the surface of the water or the leaves of the SAV. Scientists consider chlorophyll concentrations above 50 u/l to be a significant bloom and above 100 u/l to be a severe bloom.

Nitrogen is an element that is needed by all plants and animals to build proteins. Nitrogen can enter the water as run off from the land in the form of fertilizers, animal and pet waste, and human sewage from failing sewage treatment plants and septic systems. The other source of nitrogen is the air. Much of it is in the form of nitrous oxide from power plants, cars or anything that burns fossil fuels. The rest of it is in the form of ammonia from chicken houses or manure ponds; this ammonia may be coming from as far away as Ohio or North Carolina.

No matter where it comes from, when nitrogen ends up in the water it acts as a fertilizer. A small amount of nutrients is all right but too much triggers algae blooms which cause the water to become cloudy.





BALANCED SYSTEM

- **algal growth controlled**
- **water transparency high, encouraging aquatic plant growth**

EXCESS NUTRIENTS

- **algal growth excessive**
- **water transparency reduced, limiting aquatic plant growth**

Where, Oh Where, Should We Plant SAV?
Student Worksheet

Your class has been growing SAV (wild celery, sago pondweed or redhead grass) in the classroom. The plants are doing well and now it is time to plant them. The question is…where?

You know that these species of SAV prefer fresh water, although they can grow in slightly brackish water (salinity up to 10 ppt). You also know that all species of SAV need clear water so that the plants can photosynthesize. You have done some research and found out that scientists have determined that SAV needs turbidity values less than 15 NTUs or a Secchi depth greater than 0.7 meters in order to thrive.

You also realize that you will be planting the SAV near the shoreline where the water is shallow. Your choices have been narrowed down to eleven possible places located all over the Bay and tributaries, but you still do not know which ones have suitable habitat. Will you have to visit each one and do water quality sampling?

Fortunately there is an easier solution. There are monitoring stations located all over the Maryland portion of the Bay and tributaries. Some of these stations collect water quality data 24 hours a day, 7 days a week, 365 days a year. The data, which includes salinity and turbidity, can be found online. The website is called "Eyes on the Bay".

Procedure:

1. Go to www.eyesonthebay.net
2. Below the map, on the right side of the page, you will see "Optional Views:"
3. Click on "Text Only Station Menus"
4. You will be using the "Continuous Monitors:" drop-down menu. This is because these monitors are located in shallow water near the shoreline. The Monthly Monitors are located in deep water – too deep for bay grasses to survive.
5. Select the first station (Bohemia River - Long Point) and click on "Go to Station"
6. Scroll down to find the graph for salinity. Click on "See All 2008 Data" below the graph.
7. Based on the "2008 Salinity" graph, record the salinity range (minimum and maximum levels) between **April and October**.
8. Click the Back button and repeat for Turbidity. You may have to estimate an average turbidity value. SAV needs an **average** turbidity value of 15 NTUs or less. An occasional short-lived spike probably will *not* cause any harm. Again just focus on data from April through October.
9. Go back to the main page and collect data for all eleven stations. Fill in the data table as you go.

Results:

Enter all data in the data table.

Analysis:

1. What would be the best place(s) to plant your SAV? Discuss your results with other students to see if you agree.

2. Why did you focus on data from April through October?

3. Look at a map of Maryland. Locate the sites which you found suitable to plant SAV. What's special about where they're located? Which one is closest to your school?

Data Table: Where, Oh Where, Should We Plant SAV?

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Susquehanna River Havre de Grace				
Wicomico River Whitehaven				